"Study of Volumetric and Acoustical Properties of Various Aqueous Solutions of Local Anesthetical Drugs At Different Temperatures"

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Ph. D. Synopsis / Work plan

Abstract of Proposed work plan/problem**,** Entitled **"Study of volumetric and acoustical properties of various aqueous solutions of local anesthetical drugs at different temperatures"**

1. Introduction:

This research area deals with the materials and different methods used in the present study, The details of experimental techniques used for the measurement of density, volumetric and acoustical properties of anesthetical drugs in different media and at different temperature. Volumetric and acoustical properties of solutions are found to be depending upon different types of molecular interactions in solutions. Ultrasonic technique reveals very weak intermolecular interactions due to its useful wavelength range. The studies of volumetric, Acoustic and Optical properties of solutions are attracting the attention of many workers which can be judged from the recent publication in the reputed journals. The qualitative information about molecular interactions in solution can be collected from the measurement of Ultrasonic Velocity, Density and related derived thermodynamic properties. The study of molecular interactions by the measurement of volumetric and acoustic properties of different solutions has got great importance in many fields of including medicinal chemistry, industrial processes, biochemistry etc. Thermophysical properties such as density (p), viscosity (m), and ultrasonic velocity (u) give valuable information regarding the solubility, rate of diffusion, denaturation, and biological activity of drug molecules. Density and ultrasonic velocity provide information regarding the ion-ion, ion-solvent and solvent-solvent interactions and also on structural effects of solute and solvent in solution. The ultrasonic velocity and acoustical parameters of solutions are useful to understand the molecular interactions in solution. Information regarding strength and nature of molecular interactions in solution is collected from the ultrasonic technique data. Recent literature on volumetric properties of drugs and other materials of biological importance show increasing interest in this area of research. The solubility and thermodynamic properties in mixed solvents are of great importance in the Pharmaceutics.

Local anesthetics are medications that produce a reversible loss of sensation in a specific area of the body. They work by blocking nerve signals in the vicinity of their

administration. Local anesthetics can be categorized into two main groups based on their chemical structure. The pharmaceutical industry continuously strives to enhance the efficacy and safety of drugs, particularly those used in medical procedures involving local anesthesia. This study delves into the volumetric and acoustical properties of aqueous solutions containing local anesthetic drugs, with a specific focus on understanding how these properties vary at different temperatures. The investigation aims to contribute valuable insights that could optimize drug formulations and improve their performance under diverse physiological conditions. These properties are again helpful in understanding structural organization and molecular interactions like solute-solute, solute-solvent etc. in solution. Thermodynamic properties govern pharmaceutical and bio-pharmaceutical behavior of drug solutions. Also, the drug action at molecular level is understood through these thermodynamic properties of drug solutions.

2. Review of Literature and Development in the Subject (Previous work done in the relevant area):

A comprehensive review of the literature and recent developments in the study of volumetric and acoustical properties of various aqueous solutions of local anesthetic drugs at different temperatures reveals a dynamic and evolving field [1].

The intersection of physical chemistry, pharmacology, and pharmaceutical sciences in this area of research has garnered increasing attention due to its implications for drug formulation, delivery systems, and the optimization of therapeutic efficacy. There are two main classes of local anesthetics: esters and amides. These classes differ in their chemical structures and metabolism. example of ester local anesthetics include Procaine, Tetracaine etc and amide local anesthetics includes Lidocaine, Mepivacaine, Bupivacaine etc. , Kesharsingh J. Patil[2] et al have studied the Volumetric studies on the aqueous solutions of local anesthetical drug compounds like [hydrochlorides of procaine (PC HCl), lidocaine (LC HCl) and tetracaine (TC HCl)] at 298.15 K

Volumetric and acoustic properties are important tools in studying the solution behaviors of solutes and reveal valuable information about solute-solute/solute–solvent interactions[1-3] . There are very limited number of works in the literature for the volumetric and acoustic properties of anesthetic drugs and their interpretations in terms of drug–water and drug–water–co-solute interactions. [4] The mechanism of action of drug is quite complex and this needs knowledge about the molecular interactions in fluids. The data for acoustic, volumetric

and optical properties on most of drug are quite lack in aqueous media. Therefore we planned to carry out systematically the acoustic, volumetric and optical properties of drug in water at different temperatures[5-6].

The measurement of ultrasonic velocity provide very useful tool for gaining qualitative information about the solutions properties.[7-8] Thermo physical properties such as Sound velocity, Refractive index and density apparent molar volume etc. give important information for better understanding the behaviors of intermolecular interaction, associations and complexiation behavior, related structural changes and complex formation in biochemical reactions within living organisms and by using this study many researcher work on amino acid , vitamins ,carbohydrates, drugs, organic compounds and many more [9-14]. Studies on interactions of polar, non-polar compound in solution are significant and important tool for pharmaceutical industries, technical process and complex physiological processes of drug in living cell. Study of molecular interaction of drugs gives valuable information like drug behavior, solubility, aggregation and binding behavior of drug which helps to further study[15-21].

3. Objectives of Research / Proposed Hypothesis:

Objective of the present work as below:

1. To examine thermodynamic properties of important anesthetic drugs in aqueous co-solute solution in order to understand the overall structure of drugs in solution and structural fittings in solution.
2. To understand the solute-solute and solute-solvent interactions and overall behavior of the water soluble drugs molecule in different co-solute solution.
3. To produce the valuable data of performed properties such as ultrasound velocity, density, refractive index and their derived thermodynamic properties such as volumetric, acoustical and optical properties etc. for the studied water soluble anesthetic drugs molecule in different co-solute solution.
4. To evaluate thermodynamic properties of anesthetic drugs which is depend upon concentration, temperature and relative composition of different co-solute solution.
5. To give comparative account of the thermodynamic behavior of different studied anesthetic drugs.

4. Methodology to be adopted

Quantitative measurements of various thermo-acoustical/physicochemical properties such as density, sound velocity, refractive index etc. of anesthetic drugs with aqueous solution of different chemical compounds etc. will be carried out. Measurements of densities will be carried out by using single capillary pycnometer on one pan electronic balance. Sound velocity (ultrasonic velocity) of anesthetic drugs in different aqueous media will be measured using ultrasonic interferometer of fixed frequency (Model-F05, Mittal, 2 ± 0.0001 MHz). Refractive index measurements of anesthetic drug will be done using thermostatically Abbes refractometer Refractive index measurements were performed on thermostatically controlled Cyber LAB-Cyber Abbe refractometer (Amkette Analytics, ±0.0002, 1.3000 to 1.7000). Refractometer was calibrated using standard specimen (n=1.5167).

Various properties will be measured for the specified conditions like temperature, pressure, drugs concentration and various aqueous media for the respective systems. The experimental properties like density, sound velocity, refractive index etc. will be used to calculate various derived volumetric, acoustical and refractometric etc. properties for the studied anesthetic drugs

5. Importance of study/Society application:

(International status, national status & Significance of study):

Research on the topic molecular interactions of anesthetic drugs is crucial for several reasons Continuous research helps in improving the safety and efficacy of anesthetic drugs. Understanding the molecular interactions of anesthetic drugs allows researchers to develop and optimize new drugs with improved properties. Molecular research provides insights into the specific mechanisms by which anesthetic drugs induce their effects. This information is essential for anesthesiologists to administer drugs more precisely and for researchers to design interventions that target specific aspects of anesthesia. Research on molecular interactions helps in predicting and managing potential side effects and complications associated with anesthetic drugs. This is crucial for enhancing patient safety during surgeries and medical procedures. Advances in technology, such as structural biology and computational modeling, enable researchers to study molecular interactions at a finer level. This has led to more accurate predictions and a deeper understanding of how anesthetic drugs interact with their target. Research on the molecular interactions of anesthetic drugs is instrumental in advancing the field of anesthesia, leading to safer, more effective, and personalized patient care.

❖ International status

Over the last three decades, the revolutionary development in thermodynamic parameters or properties in aqueous solution have done. The researcher gives the great contribution in the investigation of physicochemical, thermodynamic properties of drugs and biologically important compounds throughout the International level.

1. C. Zelmat, T. Fergoug, M. Azayez, N. Meddah, F. Chater, H. Boudjoras, Y. Bouhadda ∗ Laboratory of Physical Chemistry of Macromolecules and Biological Interfaces, University of Mascara, Mascara 29000, Algeria thy work on the micellar action and thermal conductivity of anesthetic drugs .

2. M. Iqbal' And M. Asghar Jamal, Maqsooda Hmed And Bashira Hmed, Department of Chemistry, and Department of Pharmacy, Bahauddin Zukariya Universiv Multan, Pakistan 60800, This team worked on volumetric properties on local anesthetic drugs at 35^{o}c temperature.

3. Thomas Clayton, Kenichi Ode., Thomas Clayton MBChB (Hons) FRCA is a Specialist Trainee working in the North Western Deanery, UK. Conflicts of interest: none declared and Kenichi Ode MBChB FRCA is a Consultant Anaesthetist at Salford Royal Hospital, Salford, UK. Conflicts of interest: none declared and gives the article review on anesthetic drugs and their chemical and physical properties.

❖ National status

Apart from the international contribution some of the national researchers have also made their mark contribution on thermodynamic properties of anesthetic drug, in different aqueous media.. Different methods such as volumetric, acoustical, refractometric, transport properties etc. have been used for understanding the molecular interactions in solution of drugs. In the following sections, the selected list of researchers working in this area of research at national and international level is given

1. Vasim R. Shaikh , Dilip H. Dagade, Dilip G. Hundiwale, Kesharsingh J. Patil, School of Chemical Sciences, North Maharashtra University, Jalgaon-425001, India Department of Chemistry, Shivaji University, Kolhapur-416004, India, This group were investigated the volumetric properties and molecular interaction of some selected local anesthetic drugs with different co-solute.

2. Rajni Vashishata, Shruti Chabbaa, Vinod Kumar Aswalb and Rakesh Kumar Mahajana, Department of Chemistry, UGC-Centre for Advanced Studies Guru Nanak Dev University, Amritsar-143005, India Solid State Physics Division, Bhabha Atomic Research Centre, Mumbai 400085, India this team work on molecular interaction of anesthetic drug with ionic liquid in aqueous medium.

3. Farheen Rahman, M.Z.A. Rafiquee., Department of Applied Chemistry, Z.H. College of Engineering & Technology, Aligarh Muslim University, Aligarh, U.P. 202002, India the team worked on chemical and physical properties of some selected anesthetic drugs.

4. M.L.Parmer, O.P. Sharma and M.K. Guleria., Department of Chemistry, Himachal Pradesh University, Summer Hill Station, Shimla, India. This team worked on partial molar volume of organic acids in binary aqueous solutions of urea.

5. Amalendu Pal, Nalin Chauhan., Department of Chemistry, Kurukshetra University, Kurukshetra-136119, India. Work on thermodynamic propertis and molecular interaction.

❖ Significance of the study

The study of molecular interactions of anesthetic drugs holds significant importance for various reasons, impacting both clinical practice and drug development. To understand the nature of interaction of anesthetic drugs with aqueous solution of different chemical compound and pharmaceutical active drugs by means of The systematic measurements of Densities (p), speeds of sound (u), and viscosities (η) & parameters such as the partial molar volumes (ϕv^o), transfer partial molar volumes ($\Delta tr\phi v^o$), isentropic compressibilities (ks), partial molar isentropic compressibilities (ϕk^o), transfer partial molar isentropic compressibilities($\Delta tr\phi k^o$) and viscosity Coefficient. On the basis of this Thermo-physical parameter we obtain the data about molecular interaction. Investigation on the thermodynamic properties to provide significance information that, ultimately lead to better understanding of behavior of anesthetic drugs. Understanding the molecular interactions allows researchers to design and develop new anesthetic drugs with improved properties. Investigating molecular interactions helps clarify the mechanisms by which anesthetic drugs produce their effects molecular interactions of anesthetic drugs is essential for advancing the field, improving patient outcomes, and promoting safety in anesthesia practice. It serves as a foundation for innovation and the development of more targeted and personalized approaches to society.

6. Proposed work Plan/Formulation and structure of Study:

The proposed experimental work plan carried out as below:

FIRST YEAR: In the first year Literature survey, instrument standardization, calibrations etc. and study of physicochemical properties such as density, ultrasonic velocity and refractive index and derived thermodynamic properties of some pure solvents, solvent mixtures, aqueous solutions of selected ansthetic drugs will be carried out.

SECOND YEAR: Study of the physicochemical properties of selected water soluble ansthetic drugs in aqueous solution of three co-solutes (electrolyte, nonelectrolytes, drug, and amino acid) at different temperature will be carried out. In order to understand molecular interaction of ansthetic drugs in aqueous and aqueous co-solute solution at different temperature through thermodynamic and their derived properties. Calculation of derived properties and data fitting to standard equation will be carried out.

THIRD YEAR: Fitting the experimental data to various laws, equations and scientific generalizations so as to get the computed properties for studied system. Results will be interpreted in terms of the molecular interactions communication of the obtained result to the journals etc.

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